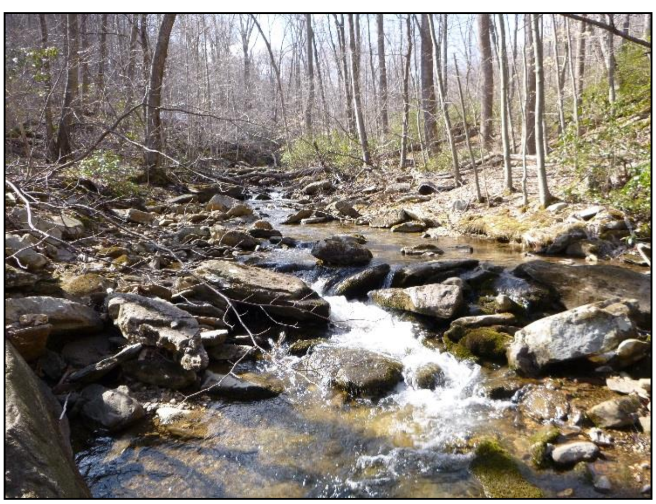
Frederick County Stream Survey 2014 Countywide Results

Prepared for

Frederick County
Office of Sustainability and
Environmental Resources
30 North Market Street
Frederick, Maryland 21701-5422



Prepared by

Versar, Inc.
9200 Rumsey Road, Suite 100
Columbia, Maryland 21045

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VERSAR

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INTRODUCTION

Freshwater streams are highly valued natural ecosystems that provide clean water and support fish and other aquatic life. Frederick County, Maryland, conducts a stream monitoring and assessment program to collect information on the health of the County's streams. Findings will be used to help guide the County's watershed management programs to better protect and restore local waters.

The Frederick County Stream Survey (FCSS) is a program to assess the status of County streams in terms of water quality, biological condition, and habitat. The survey employs a statistical design, using a random sampling approach to draw inferences about stream condition in each of the County's 20 watersheds (Figure 1) and in larger areas such as the Lower Monocacy watershed and the entire County. The FCSS was designed to answer key questions about the condition of Frederick County's watersheds and streams and, in particular, the stressors affecting those streams. The site selection and stream sampling methods are based on Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS).

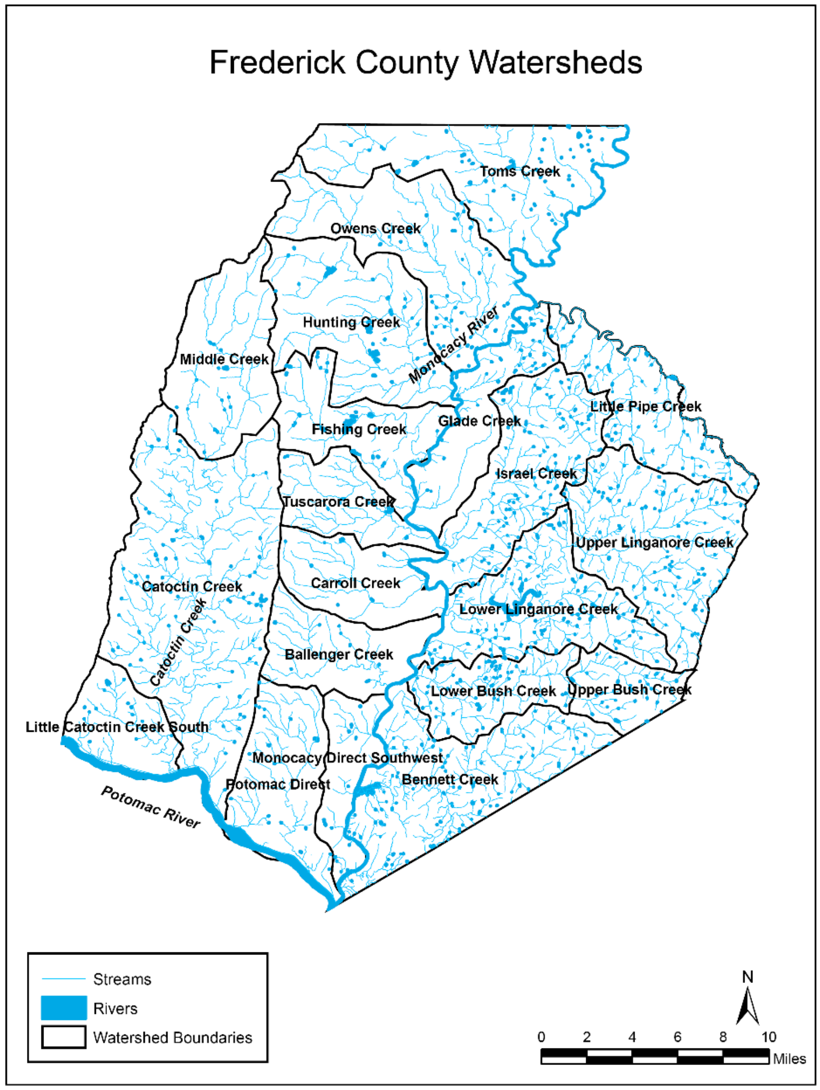

Figure 1. Watersheds located in Frederick County, Maryland

In 2007, a Pilot Study was launched in the Bennett and Catoctin Creek watersheds to help develop, test, and refine the design and sampling protocols for the full FCSS (Versar Inc. 2009). The first round of the FCSS began in 2008 and continued through 2011. For each of the 2008-2011 sampling years, field crews contacted landowners and sampled 50 randomly selected sites stratified across the 20 watersheds in the County. Following methods detailed in the design report (Perot et al. 2008), data were collected on water quality, physical habitat, and biological communities at each of the stream sites. This information was used to make an assessment of stream conditions countywide. Because the sites were randomly selected, estimates of the extent of streams (percentage of stream miles) in different condition classes for each assessment measure could be made. Reports presenting the results of each year of sampling, as well as a final Round 1 report, are available at http://www.watershed-alliance.com/mcwa_pubs.html.

Round 2 of the FCSS began in 2013 and will continue through 2016. This report presents several key findings from 2014, the second year of Round 2 sampling. The report includes answers to each of the study questions posed and will compare Round 1 and Round 2 results. A final report, produced in 2016, will ultimately provide information on stream condition and related stressors by individual watershed, in addition to the Countywide information provided every year.

Overall, biological condition of streams in Frederick County in 2014 was rated as poor, which is the same narrative category as the Round 1 results. Stream condition was affected by a variety of land use, habitat, and water quality factors. Stream condition results and an assessment of key stressors are highlighted in the following sections:

- Land Use
- Habitat
- Water Quality
- Biological Condition

2014 FCSS RESULTS

Land Use

Watershed land use is an indicator of how human activities affect a stream. A watershed is an area of land that drains to a particular body of water. Watersheds form natural geographic units for assessing impacts on streams because land use within the watershed upstream of a specific stream site is representative of many of the human activities affecting the stream at that point.

Streambank erosion in a residential neighborhood

Conversion of naturally vegetated lands to urban and agricultural uses can result in serious impacts to streams and their aquatic inhabitants. In urban and suburban areas, impervious surfaces, such as roads, parking lots, sidewalks, and rooftops, cause a rapid increase in the rate that water is transported from the watershed to its stream channels. Effects include an increase in the variability of stream flows (more "flashy" flows), increased streambank erosion, habitat degradation caused by channel instability, increased pollutant runoff, elevated temperatures, and losses of biological diversity. Reviews of stream research in numerous watersheds indicate that impacts on stream quality are commonly noted at about 10% coverage by impervious surface (Schueler et al. 2009). Effects on sensitive species may occur at even lower levels (Roth et al. 1999). Agricultural impacts upon stream resources can include runoff of sediment, nutrients, and other pollutants, and increased erosion leading to habitat and water quality degradation. However, agricultural effects may be complex, as they may include contributions of lime (which can neutralize harmful acid rain inputs) and nutrients (which can, in some cases, enhance stream productivity).

Using data from the Maryland Department of Planning (2010), Frederick County has a diverse mix of land uses (Figure 2). Overall, 48% of the County is agriculture, 33% is forest, and 17% is urban/suburban (2% is "other", including wetlands/water and barren lands, which include areas of bare rock as well as landfills and quarries).

One way of measuring stream condition, especially as it related to land use, is to estimate the percentage of stream miles with a particular trait, for example, "The percentage of stream miles in Frederick County with high Total Nitrogen." This number is a weighted percentage of the sites that fall into the category of interest divided by the total number of sites sampled in the County. The weighting used is a ratio of the number of stream miles in a particular site's subwatershed divided by the total number of stream miles in the County. This weighting removes the bias introduced by forcing the same number of sites into subwatersheds of varying sizes.

In the FCSS, land uses were characterized within the individual catchment areas upstream of sampled sites (Appendix Table 1). In 2014, an estimated 48% of stream miles in the County had greater than 10% urban land use in their catchments (22% of stream miles had greater than 25% urban land use; land use data from 2010 MDP). These results indicate that a substantial proportion of Frederick County streams are likely to be influenced by urban/suburban activities.

Stream located in agricultural land

The extent of forested land was also characterized. For a comparison, in a study which established reference and degraded conditions for streamside salamanders (an indicator of stream conditions, Southerland et al. 2004), streams with greater than or equal to 75% forested land use in upstream catchments were considered high-quality reference streams and streams with less than or equal to 10% forested land use in upstream catchments were considered degraded. Based on 2014 data, only 10% of stream miles in Frederick County had greater than or equal to 75% forested land use upstream, while 18% of stream miles had less than or equal to 10% forested land use upstream (including 2 sites with less than 1% forested land use in their upstream catchments). In all, 18% of stream miles had more than 90% agriculture in upstream catchments. The average percentage of catchment area as agriculture was 42%, compared with an average of 18% urban and 33% forest.

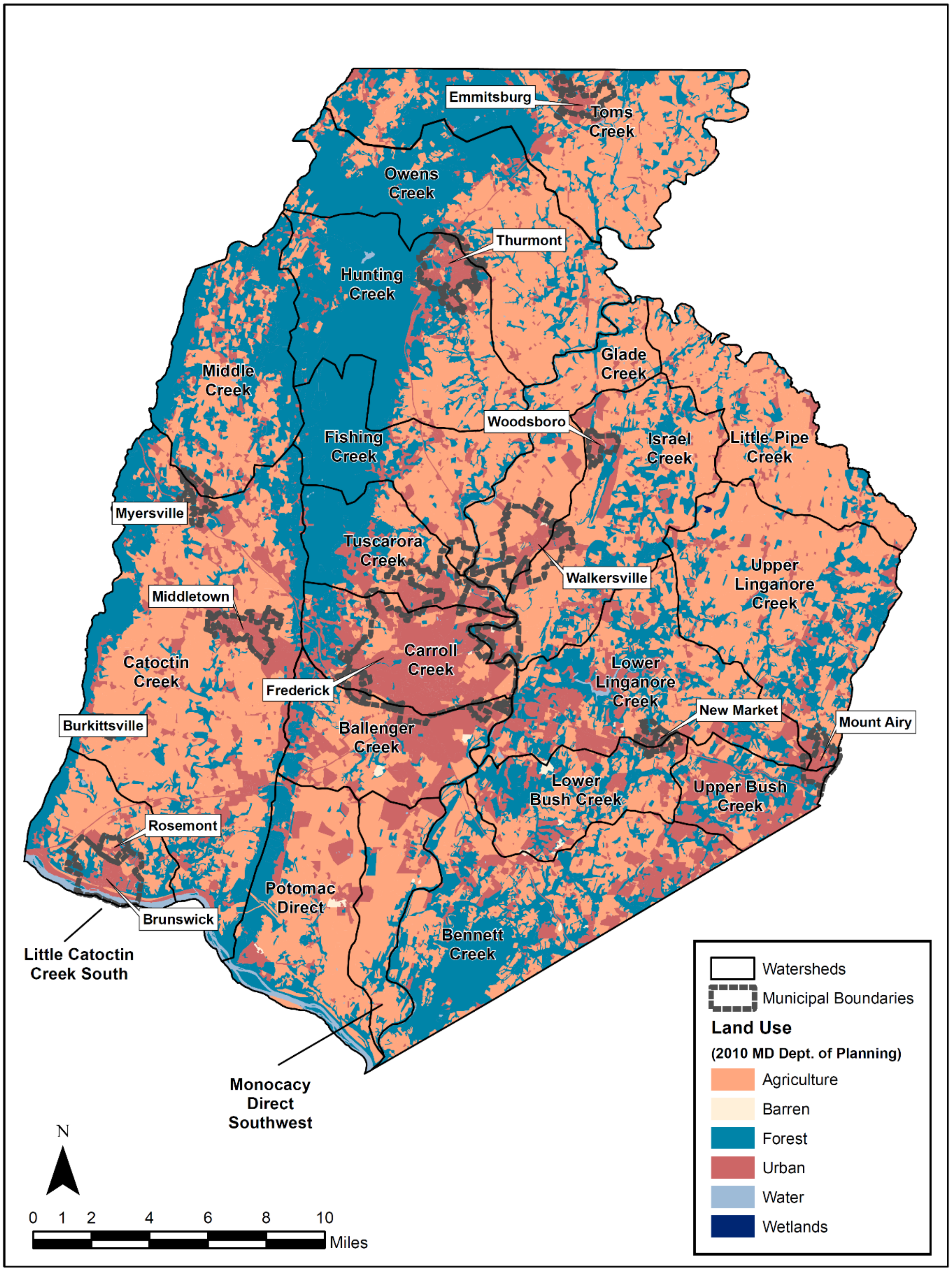

Figure 2. Land use in Frederick County, Maryland

What percentage of stream miles that are in good condition are near the thresholds of impervious surface likely to cause degradation (i.e., are most vulnerable)?

Impervious surfaces are mainly constructed surfaces – rooftops, sidewalks, roads, and parking lots – covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water, and prevent precipitation and meltwater from infiltrating soils. Soils compacted by urban development are also highly impervious. Impervious surfaces increase runoff, reduce evapotranspiration, have high thermal conductivities, and contribute to non-point source pollution problems. As a rule, water quality problems increase with increased impervious surface cover, leading to degraded stream conditions (http://chesapeake.towson.edu/landscape/impervious/what_imp2.asp). Schueler et al. (2009) define four categories of urban streams based on how much impervious surface exists in their upstream catchment:

- Sensitive – less than 10% impervious surface in the upstream catchment, are generally able to maintain their hydrologic function and support good to excellent aquatic diversity;
- Impacted – 10 to 25% impervious surface in the upstream catchment, show clear signs of declining stream health;
- Non-supporting – 25 to 60% impervious surface, no longer support their designated uses in terms of hydrology, channel stability, habitat, water quality, or biological diversity. They have become so degraded that it may be difficult to fully recover predevelopment stream function; and
- Urban drainage – greater than 60% impervious surface and basically just function as conduits for floodwater, they consistently have poor habitat and biodiversity scores.

In the 2014 FCSS, the average percent imperviousness in catchments upstream of sample sites was 4.6%, well below the threshold for sensitive streams (Appendix Table 2). Impervious surface values ranged from less than one percent to 13%. An estimated 94% of stream miles in the County fell into the "sensitive" streams category, while 6% of stream miles were "impacted". No streams sampled were "non-supporting" or "urban drainage".

In 2014, two sites had impervious surface values in their upstream catchments greater than 10%. These sites were in the Ballenger Creek and Catoctin Creek watersheds and were rated "Poor" by the Benthic Index of Biotic Integrity (BIBI). At these sites especially, just a small increase in the impervious surface in the upstream catchment could result in a dramatic worsening in stream conditions due to potential increased stormwater flow.

Habitat

Stream health, as characterized by the condition of biological communities, is often directly correlated to the quality of physical habitat within a stream. Habitat loss and degradation have been identified as critical factors affecting biological diversity in streams worldwide. Habitat degradation can result from a variety of human impacts occurring within the stream itself or in the surrounding watershed. Typical instream impacts include sedimentation, channelization, and bank

Example of diverse instream habitat

erosion. Urban development, timber harvesting, agriculture, livestock grazing, and the draining or filling of wetlands are well-known examples of human activities that can affect stream habitat at a watershed scale.

These human activities may cause changes in vegetative cover, sediment loads, hydrology, and other factors influencing stream habitat quality. The amount of forest, meadow, and other vegetative cover in a watershed regulates the flow of water, nutrients, and sediments to adjacent streams. In watersheds affected by human land uses, riparian (streamside) forests can act as a filter, reducing the amounts of nutrients, sediments, and other pollutants reaching streams. They also provide local benefits of shade, leaf litter to feed the aquatic food web, and large woody debris, which in turn provides cover and forms pool and riffle microhabitats preferred by fish and other aquatic animals. The loss of watershed or riparian vegetation increases the potential for overland and channel erosion, often increasing the siltation of stream bottoms and obliterating the clean gravel surfaces used by many fish species as spawning habitat. Stream bottoms that become embedded with increased sediment offer poor habitat for many bottom-dwelling species. The impervious surfaces of urban areas and the direct connection of runoff to storm water pipes or channelized streams alter runoff patterns and create "flashy" streams with more extreme high and low flows, increased scouring, and streambank erosion. These altered flows accelerate downcutting and widening of stream channels.

Example of extreme streambank erosion

The FCSS collects data on many aspects of physical habitat, including the extent and type of vegetated riparian buffer, the severity of bank erosion observed, and an overall indicator of habitat quality. The Physical Habitat Index (PHI) for Maryland streams was developed using data from the Maryland Biological Stream Survey (Paul et al., 2002). This index combines several measures of physical habitat characteristics into one value that is then compared to minimally impacted ("reference") sites throughout the state.

What percentage of stream miles exhibit severe bank erosion?

Bank erosion was classified from None to Severe (0-3; see Table 1) Bank erosion in the County's streams ranged from none to severe (Appendix Table 3). In 2014, 16% of stream miles in the County showed no indications of bank erosion, while 16% of stream miles exhibited severe erosion (Figure 3).

Table 1. Bank Erosion and riparian width sum classes

Category	Erosion Severity Class	Riparian Width Sum
0	None	
1	Minimum	≤ 15 m
2	Moderate	15 m to ≤ 30 m
3	Severe	30 m to ≤ 60 m
4		> 60 m

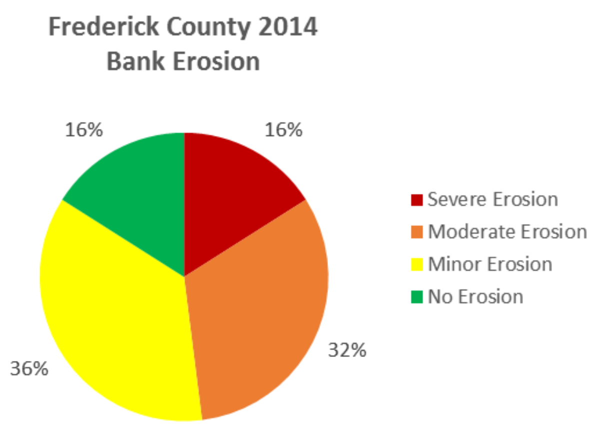

Figure 3. Percentage of stream miles in each bank erosion category for the 2014 Frederick County Stream Survey

What percentage of stream miles lack vegetated riparian buffers?

For the purposes of this report, the riparian buffer width on both sides of the stream was summed together as a measure of riparian buffer integrity, and riparian buffer categories were assigned based on natural breaks in the data (Table 1). An estimated 20% of stream miles in the County had combined vegetated riparian buffer widths less than 15 meters, while 58% of stream miles in the County had vegetated riparian buffers of at least 60 meters (Figure 4).

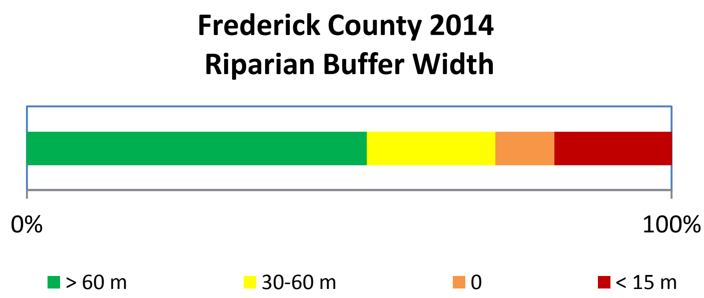

Figure 4. Percentage of stream miles in riparian buffer width categories for the 2014 Frederick County Stream Survey

Site-specific details for bank erosion and riparian buffer width can be found in Appendix Table 3.

What percentage of stream miles are rated as Severely Degraded by the Physical Habitat Indicator?

The Physical Habitat Indicator categories (as well as the Benthic Index of Biotic Integrity categories discussed later in this report) can be found in Table 2. Site-specific details for the BIBI and PHI scores can be found in Appendix Table 4.

Table 2. Thresholds for condition classes (Good, Fair, Poor, Very Poor) for BIBI and PHI scores in accordance with MBSS.

Condition Class	BIBI Range	PHI Range	Description (Roth et al. 1999)
Good/Marginally Degraded	4.00 – 5.00	81 – 100	Comparable to reference streams considered to be minimally impacted.
Fair/ Partially Degraded	3.00 – 3.99	66-80	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of minimally impacted streams.
Poor/ Degraded	2.00 – 2.99	51-65	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of minimally impacted streams.
Very Poor/Severely Degraded	1.00 – 1.99	0-50	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of minimally impacted streams.

In 2014, 28% of stream miles in the County were rated as Severely Degraded and 12% were Marginally Degraded based on the Physical Habitat Indicator (Figure 5).

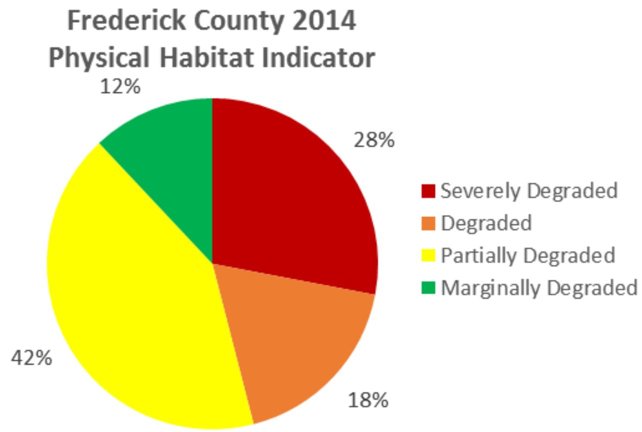

Figure 5. Percentage of stream miles in Physical Habitat Indicator (PHI) categories for the 2014 Frederick County Stream Survey

Water Quality

Nutrients such as nitrogen and phosphorus are important for life in all aquatic systems. In the absence of human influence, streams contain background levels of nutrients that are essential to the survival of the aquatic plants and animals. However, since the time of European settlement, the amount of nitrogen and phosphorus in many North American stream systems has increased, as a result of human influences such as agricultural runoff, wastewater discharge, and urban/ suburban runoff.

Stream located in agricultural field, with possible nitrogen inputs

Elevated nitrogen is one contributor to nutrient enrichment in Frederick County streams. Excessive nitrogen loading may lead to the eutrophication of a water body, particularly in downstream estuaries like the Potomac River and Chesapeake Bay. Eutrophication can cause algal blooms, which can lead to decreased levels of dissolved oxygen in the water. Prolonged exposure to low dissolved oxygen conditions can asphyxiate fish, shellfish, and other animals.

Estimates of nitrogen sources in Maryland, as presented in the Chesapeake Bay Total Maximum Daily Load (TMDL; Chesapeake Bay Phase 5.3 Watershed model, 2009 Scenario), are that 44% of nitrogen is from agricultural sources, 15% from developed land, 15% from forest, and 25% from point sources such as wastewater treatment plants.

The FCSS records field measures of dissolved oxygen and other water quality parameters and collects water samples for laboratory analysis of nitrogen and phosphorus (Appendix Table 5). The water quality thresholds for these parameters can be found in Table 3. These thresholds are those used for the MBSS and derived from expert judgement (Ray Morgan, University of Maryland, Frostburg, personal communication).

In addition, the FCSS also samples the following water quality parameters:

- Dissolved Organic Carbon and Turbidity, which can be used to assess instream sediment issues
- Orthophosphate and numerous forms of Nitrogen including: Ammonia, Nitrite, Nitrate/Nitrite, Nitrate, and Total Kjehldahl Nitrogen, which all can be used for source determination

Strict thresholds have not been developed for these water quality parameters, so they are not discussed in this report in detail, but the results can be found in Appendix Table 5.

Table 3. Water quality thresholds (mg/l) for nutrients measured at sites sampled in the FCSS (Southerland et al. 2007)

Parameter	Low	Moderate	High
Total Nitrogen	< 1.5	1.5 – 7.0	> 7.0
Total Phosphorus	< 0.025	0.025 – 0.070	> 0.070

What is the geographic distribution of streams with high amounts of Total Nitrogen?

In general, the western portion of the County seemed to have slightly lower concentrations of Total Nitrogen than the easternmost portion (Figure 6). Average Total Nitrogen across the County was 3.13 mg/L.

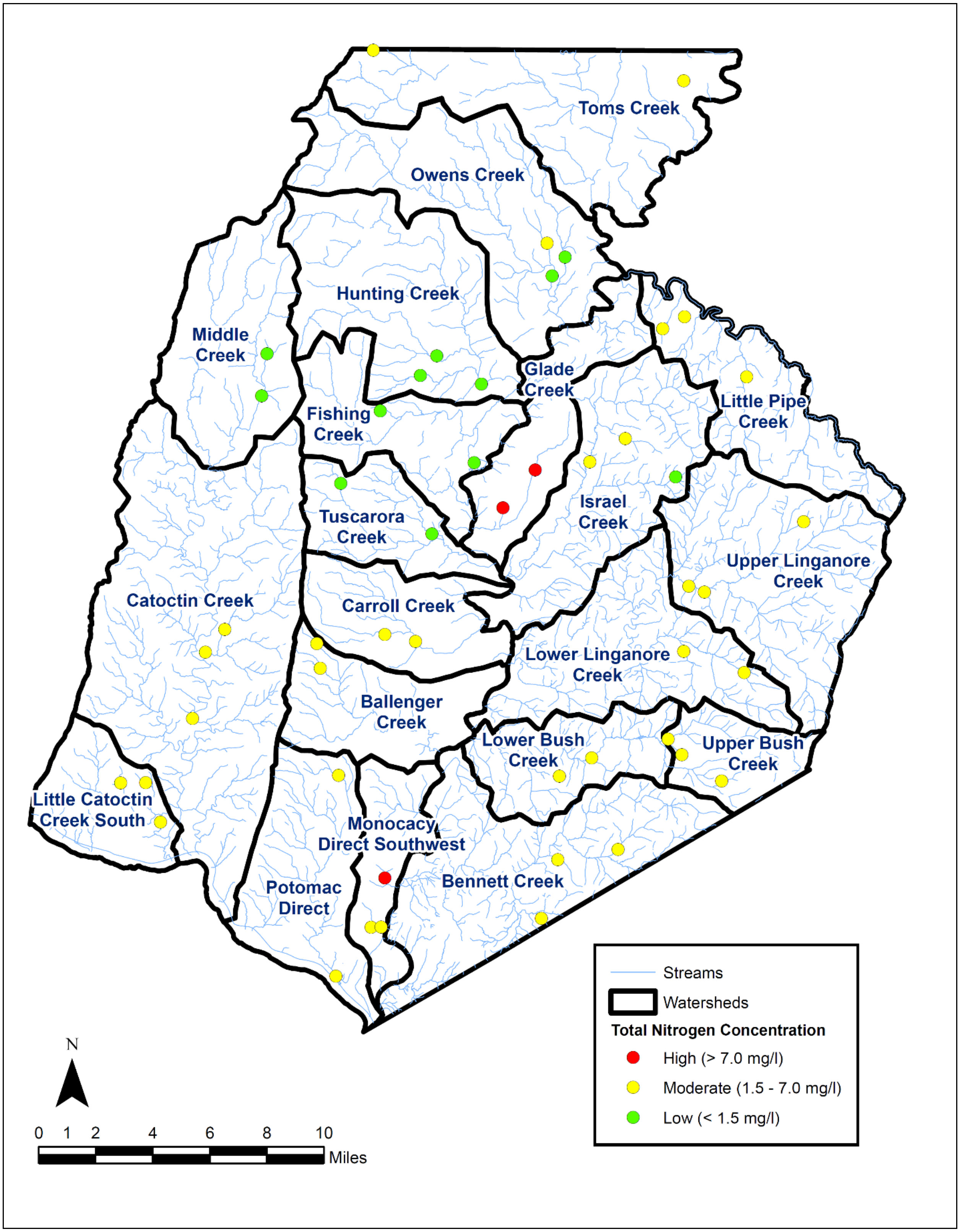

Figure 6. Distribution of Total Nitrogen concentration (mg/L) at sites sampled by the 2014 Frederick County Stream Survey

What is the geographic distribution of streams with high amounts of Total Phosphorus?

Total Phosphorus concentration was Low to Moderate at most sites throughout the County in 2014. Six sites (Two in Glade Creek, two in Catoctin Creek, one in Upper Linganore Creek, and one in Toms Creek) had Total Phosphorus greater than the MBSS "High" standard of 0.07 mg/L (Figure 7). Note that these results are based on a single sample at each site, which provides a snapshot of conditions throughout the County, but does not fully characterize long-term conditions at any particular site.

What percentage of stream miles have high levels of Total Nitrogen or Total Phosphorus?

For the 2014 FCSS, 6% of stream miles in the County had Total Nitrogen levels that fell in the "High" category and 12% of stream miles had Total Phosphorus levels that fell in the "High" category.

What percentage of stream miles have dissolved oxygen less than the state water quality standard at the time of sampling?

The state water quality standard for dissolved oxygen is 5 mg/l. Based on spring 2014 sampling, no stream miles in Frederick County had a dissolved oxygen level less than 5 mg/l at the time of sampling. Low dissolved oxygen issues associated with high temperatures can be more common during summer, rather than spring, when sampling took place.

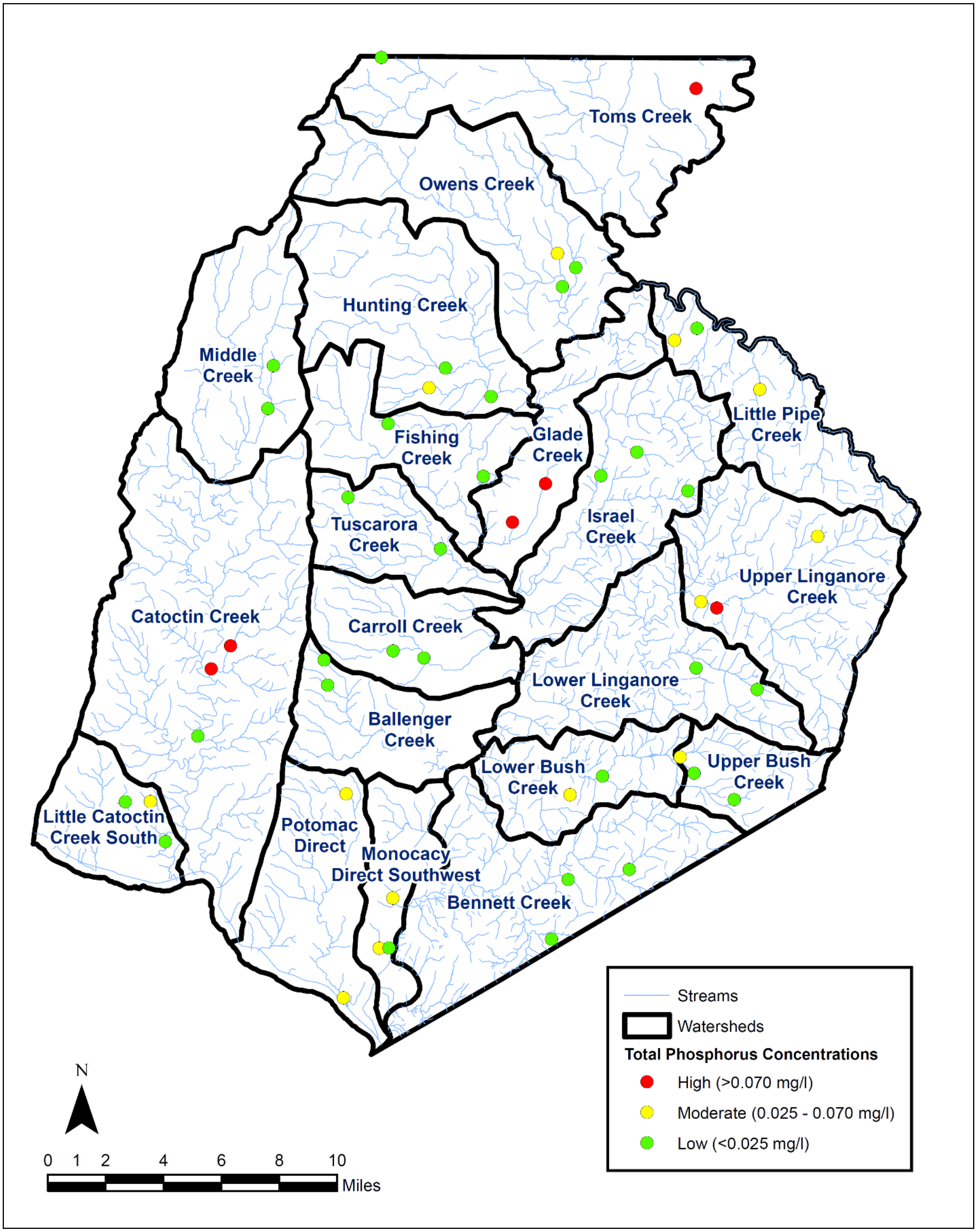

Figure 7. Distribution of Total Phosphorus concentration (mg/L) at sites sampled by the 2014 Frederick County Stream Survey

Biological Community (adapted from DNR 2004)

Freshwater benthic macroinvertebrates are bottom-dwelling aquatic animals without backbones that are larger than 0.5 millimeter long. These animals live in water on rocks, logs, sediment, debris and aquatic plants during some period in their life. Stream benthic macroinvertebrates include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Field crew sampling for benthic macroinvertebrates

Benthic macroinvertebrates are an important part of the food chain. Many invertebrates feed on algae and bacteria, which are on the lower end of the food chain. Some shred and eat leaves and other organic matter that enters the water. Because of their abundance and position as "middlemen" in the aquatic food chain, benthic macroinvertebrates play a critical role in the natural flow of energy and nutrients. As they die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain.

Unlike fish, benthic macroinvertebrates cannot move around much, so they are less able to escape the effects of sediment and other pollutants that diminish water quality and degrade habitat. Therefore, benthic macroinvertebrates can provide reliable information on stream degradation. Benthic macroinvertebrates represent an extremely diverse group of aquatic animals and the large number of species possess a wide range of responses to stressors such as organic pollutants, sediments, and toxic chemicals. They can serve as an early warning sign of declines in environmental quality.

The Benthic Index of Biotic Integrity (benthic IBI or BIBI) is a stream assessment tool that evaluates stream biological integrity based on characteristics of the various benthic organisms present at a site. Biological integrity is defined as the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region (Karr and Dudley 1981).

Frederick County sites were evaluated using the benthic IBI developed for the Maryland Biological Stream Survey (for detailed methods, see Southerland, et al. 2005). BIBI scores are determined by comparing the benthic assemblages at each site to those found at minimally impacted ("reference") sites within the same region. In 2013, BIBI scoring was modified to update calculations to match minor adjustments made by the Maryland Department of Natural Resources (DNR) in methodology (i.e., exclude several families of benthic macroinvertebrates (especially Acariformes mites) and to include only the primary habit(?) listed. Site-specific BIBI results were used to estimate the extent of streams within the study watersheds that were in good, fair, poor, and very poor condition with respect to the biotic integrity of the benthic community.

What percentage of stream miles are in very poor, poor, fair, or good condition according to the benthic IBI?

The benthic IBI average score for the County was 2.71 (Poor), with scores spread throughout the County. Eighteen percent of stream miles scored Very Poor, 42% scoring Poor, 32% scoring Fair, and only 8% of stream miles scoring Good (Figure 8).

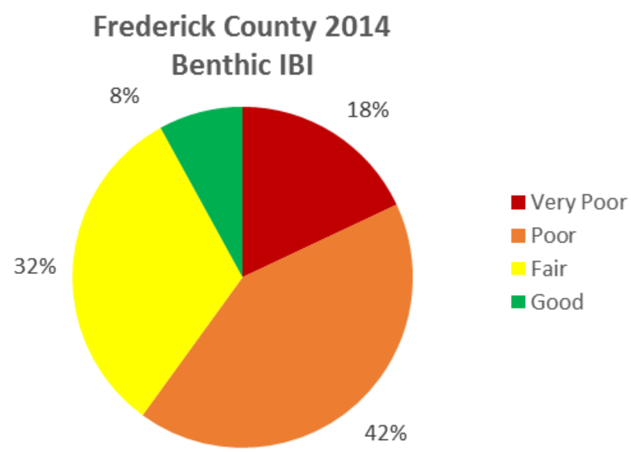

Figure 8. Percentage of stream miles in each BIBI category for the 2014 Frederick County Stream Survey

What is the geographic distribution of benthic IBI scores throughout the County?

Benthic IBI scores are somewhat evenly distributed, with the southern and eastern portions of the County scoring slightly worse than the northern and western portions (Figure 9).

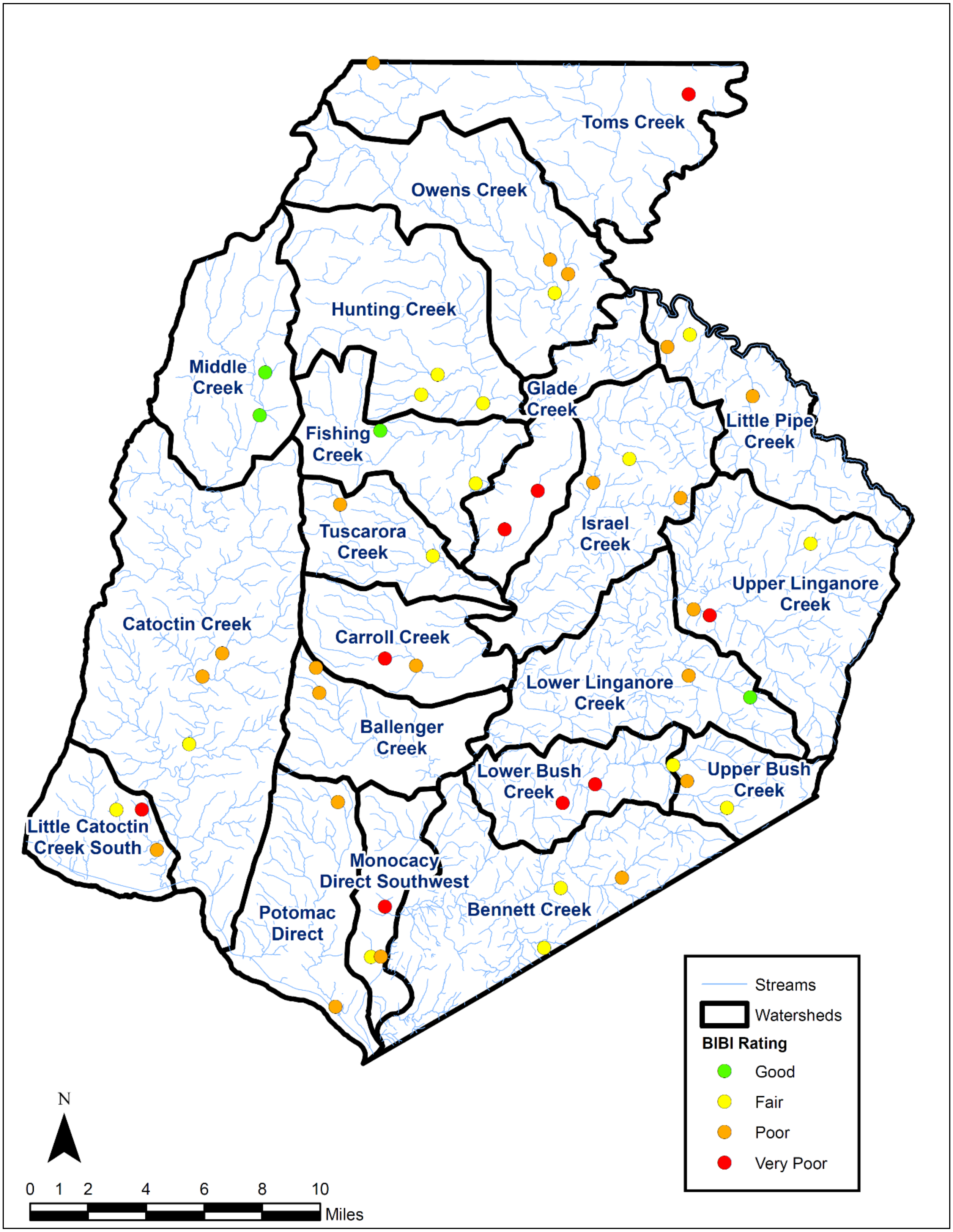

Figure 9. Distribution of Benthic IBI scores at sites sampled by the 2014 Frederick County Stream Survey

What percentage of stream miles have suitable physical habitat and would be expected to have desired species if other stressors were absent (i.e., are good candidates for restoration)?

The relationship between Physical Habitat Indicator Score and BIBI was not a strong one (Figure 10; $r^2 = 0.05$), in the 2014 FCSS. As would be expected, many sites with good PHI scores had Fair or Good BIBI scores. But, there were also many sites that were an exception to this relationship. For example, half of the sites with PHI scores greater than 80 had BIBI scores less than or equal to 3.00. These sites may be good sites for restoration, given the potential that BIBI scores might improve in the absence of other stressors, such as poor water quality.

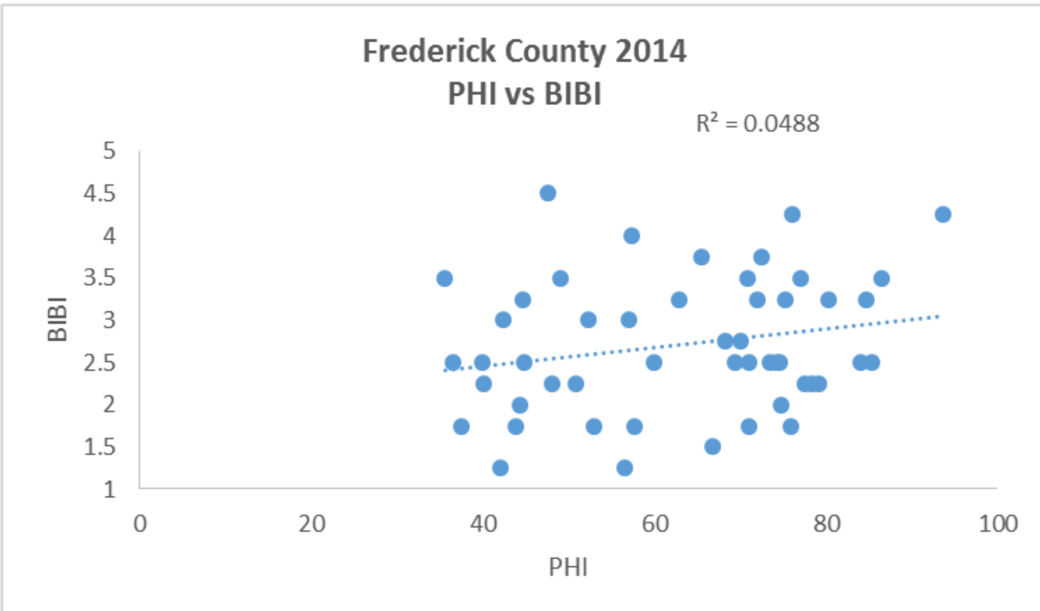

Figure 10. Regression graph of Physical Habitat Indicator (PHI) scores vs. BIBI scores for sites sampled in the 2014 FCSS

In the 2014 FCSS, the relationship between urban land use in the catchments upstream of the sample sites and the BIBI at those sites was not significant ($r^2 < 0.02$). This result is most likely due to the fact that there were not many sites with high amounts of urban land in the upstream catchments, However, the relationships of agricultural land use and forested land use to BIBI (r^2=0.09 and r^2=0.024, respectively) did show obvious trends. As might be expected, BIBI scores decreased with greater agricultural land use and increased with greater forested land use (Figure 11).

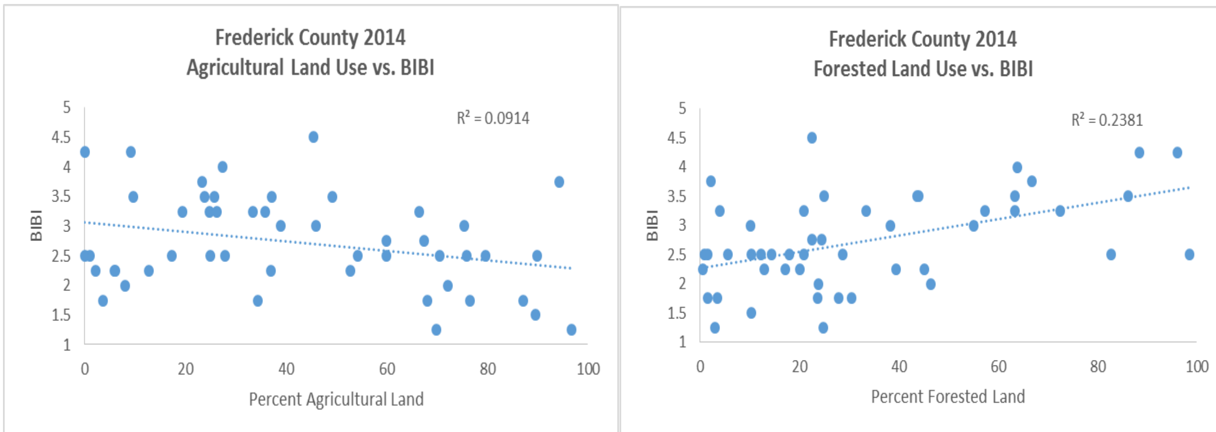

Figure 11. Regression graphs of the percentage of agricultural land use and the percentage of forested land use in catchments upstream of sample locations, vs. BIBI scores for sites sampled in the 2014 FCSS.

COMPARISON WITH ROUND 1 RESULTS

With the completion of 2014 sampling, there are now six years of data that can be compared over time. Table 4 and Figure 12 show the distribution of BIBI scores for each year of the FCSS. In years 2008, 2011, 2013, and 2014 the mean BIBI score was Poor (BIBI scores of 2.81 ± 0.71, 2.81 ± 0.92, 2.84 ± 0.87, and 2.71 ± 0.79 respectively. In the years 2009 and 2010, the mean BIBI score was Fair (BIBI scores of 3.14 ± 0.80 and 3.14 ± 0.74, respectively). The narrative rating of the biological condition did not change significantly over time; an Analysis of Variance (ANOVA) test for differences amongst the years showed that the changes in BIBI score were not significant ($p < 0.0001$).

Table 4 and Figure 12 also show the distribution of physical habitat scores for each year of the FCSS. In years 2008, 2010, and 2013, the mean PHI score was Partially Degraded (PHI scores of 66.4 ± 18, 68.4 ± 15, and 66.6 ± 15, respectively. In the years 2009, 2010, and 2014 the mean PHI score was Degraded (PHI scores of 63.9 ± 17, 63.2 ± 15, and 63.1 ± 16, respectively). The narrative rating of the biological condition did not change significantly over time; an ANOVA test for differences amongst the years showed that the changes in PHI score were not significant ($p < 0.0001$).

After each additional year of sampling, results will be added to this analysis in order to form a picture of change over time in Frederick County stream condition. Additionally, upon the completion of Round 2, these comparisons can be made at the watershed level.

Table 4. Mean Benthic IBI and Physical Habitat Indicator Scores for all years of the FCSS 2008-2014

		Mean Benthic IBI Score	Narrative Rating	Mean Physical Habitat Indicator Score	Narrative Rating
Round 1	2008	2.81	Poor	66.43	Partially Degraded
	2009	3.14	Fair	63.93	Degraded
	2010	3.14	Fair	68.45	Partially Degraded
	2011	2.81	Poor	63.21	Degraded
Round 2	2013	2.84	Poor	66.61	Partially Degraded
	2014	2.71	Poor	63.12	Degraded

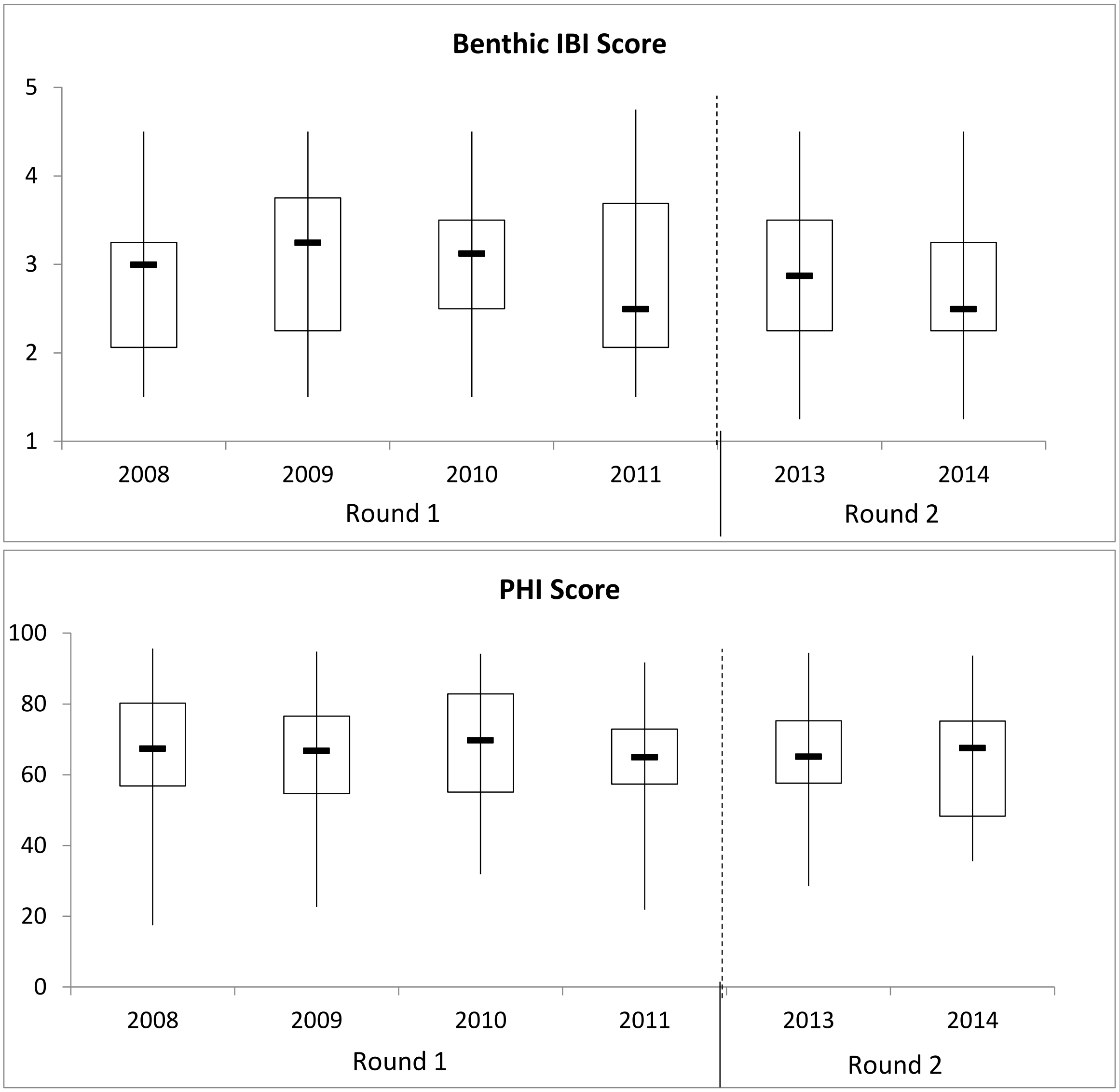

Figure 12. Box and whisker plot showing distribution of BIBI and PHI scores for each year sampled in the FCSS (Round 1 – 2008-2011 and Round 2 – 2013-2014). Dark horizontal line indicates median score; upper and lower bounds of boxes indicate 75th and 25th percentiles, respectively; and upper and lower tails indicate highest and lowest scores, respectively.

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APPENDIX

Appendix Table 1. Land use percentages in catchments upstream of sites sampled in the 2013-2014 FCSS						
Site	**Percent Urban**	**Percent Agriculture**	**Percent Forest**	**Percent Wetlands**	**Percent Water**	**Percent Other**
2013						
BALL-110-R-2013	43.62	12.78	43.60	0.00	0.00	0.00
BALL-112-R-2013	61.89	7.27	30.84	0.00	0.00	0.00
BALL-213-R-2013	35.82	36.88	27.30	0.00	0.00	0.00
BENN-101-R-2013	18.46	40.05	41.49	0.00	0.00	0.00
BENN-102-R-2013	0.00	100.00	0.00	0.00	0.00	0.00
BUSL-103-R-2013	12.99	84.01	2.99	0.00	0.00	0.00
BUSL-107-R-2013	45.05	20.16	26.92	0.00	0.00	7.87
BUSL-301-R-2013	38.02	34.25	27.59	0.00	0.07	0.07
BUSU-113-R-2013	44.98	33.79	21.23	0.00	0.00	0.00
BUSU-209-R-2013	43.18	39.23	17.03	0.00	0.56	0.00
CARR-101-R-2013	5.82	12.45	81.72	0.00	0.00	0.00
CARR-109-R-2013	47.83	47.16	0.00	0.00	1.71	3.31
CARR-113-R-2013	42.52	12.36	45.12	0.00	0.00	0.00
CATO-102-R-2013	19.03	74.57	6.41	0.00	0.00	0.00
CATO-106-R-2013	22.50	10.73	66.78	0.00	0.00	0.00
FISH-106-R-2013	3.06	96.94	0.00	0.00	0.00	0.00
FISH-112-R-2013	1.20	86.92	11.88	0.00	0.00	0.00
FISH-211-R-2013	8.40	14.12	77.29	0.00	0.19	0.00
GLAD-104-R-2013	18.29	78.62	3.09	0.00	0.00	0.00
GLAD-108-R-2013	3.54	71.12	25.34	0.00	0.00	0.00
GLAD-112-R-2013	17.28	80.55	2.13	0.00	0.00	0.05
HUNT-101-R-2013	8.12	3.68	88.20	0.00	0.00	0.00
HUNT-105-R-2013	1.03	0.88	98.09	0.00	0.00	0.00
ISRA-104-R-2013	34.83	65.00	0.18	0.00	0.00	0.00
ISRA-203-R-2013	15.61	60.52	23.79	0.00	0.08	0.00
LCCS-102-R-2013	6.77	43.62	49.61	0.00	0.00	0.00
LCCS-201-R-2013	11.87	62.55	25.22	0.00	0.36	0.00
LINL-103-R-2013	22.93	21.33	55.73	0.00	0.00	0.00
LINL-108-R-2013	1.04	71.03	27.93	0.00	0.00	0.00
LINL-114-R-2013	12.85	86.79	0.37	0.00	0.00	0.00
LINU-104-R-2013	19.63	50.68	29.70	0.00	0.00	0.00
LINU-107-R-2013	0.23	88.19	11.59	0.00	0.00	0.00
LIPI-106-R-2013	6.59	91.88	1.56	0.00	0.00	0.00
LIPI-110-R-2013	0.57	99.43	0.00	0.00	0.00	0.00
MIDD-101-R-2013	8.29	34.37	57.34	0.00	0.00	0.00
MIDD-106-R-2013	1.96	28.18	69.86	0.00	0.00	0.00
MIDD-108-R-2013	11.39	22.82	65.76	0.00	0.03	0.00
MODS-101-R-2013	1.96	98.01	0.02	0.00	0.00	0.00
MODS-111-R-2013	4.05	83.75	11.72	0.00	0.47	0.00

Appendix Table 1. (Continued)						
Site	**Percent Urban**	**Percent Agriculture**	**Percent Forest**	**Percent Wetlands**	**Percent Water**	**Percent Other**
OWEN-101-R-2013	4.41	90.64	4.96	0.00	0.00	0.00
OWEN-202-R-2013	9.59	54.87	35.39	0.00	0.15	0.00
POTD-106-R-2013	0.00	36.89	63.11	0.00	0.00	0.00
POTD-107-R-2013	0.00	15.59	84.41	0.00	0.00	0.00
POTD-301-R-2013	24.11	60.82	13.31	0.00	0.18	1.58
TOMS-105-R-2013	2.69	80.34	16.97	0.00	0.00	0.00
TOMS-106-R-2013	9.75	61.04	28.94	0.00	0.27	0.00
TOMS-304-R-2013	9.72	37.06	50.54	1.16	0.48	0.32
TUSC-101-R-2013	1.78	0.00	97.48	0.00	0.74	0.00
TUSC-106-R-2013	0.00	39.81	60.19	0.00	0.00	0.00
TUSC-407-R-2013	10.00	22.74	67.11	0.00	0.15	0.00
2014						
BALL-116-R-2014	55.19	6.11	39.51	0.00	0.00	0.00
BALL-118-R-2014	47.13	7.97	46.42	0.00	0.00	0.00
BENN-116-R-2014	61.86	27.84	10.30	0.00	0.00	0.00
BENN-121-R-2014	17.32	37.13	44.02	0.00	0.00	1.52
BENN-219-R-2014	7.09	49.13	43.60	0.00	0.18	0.00
BUSL-123-R-2014	11.22	87.22	1.56	0.00	0.00	0.00
BUSL-316-R-2014	37.83	34.32	27.95	0.00	0.07	0.07
BUSU-116-R-2014	45.65	33.42	20.93	0.00	0.00	0.00
BUSU-123-R-2014	97.42	2.12	0.46	0.00	0.00	0.00
BUSU-221-R-2014	40.69	26.25	33.43	0.00	0.00	0.17
CARR-216-R-2014	17.78	3.58	30.43	0.00	0.00	0.00
CARR-327-R-2014	24.89	12.72	20.12	0.00	0.10	0.20
CATO-220-R-2014	45.85	36.92	17.14	0.00	0.09	0.00
CATO-327-R-2014	34.17	52.76	12.96	0.00	0.12	0.00
CATO-417-R-2014	15.74	45.91	38.34	0.00	0.04	0.00
FISH-119-R-2014	3.93	0.00	96.07	0.00	0.00	0.00
FISH-223-R-2014	8.27	19.33	63.45	0.00	0.15	0.00
GLAD-117-R-2014	19.97	76.63	3.47	0.00	0.00	0.00
HUNT-221-R-2014	2.64	24.79	72.58	0.00	0.00	0.00
HUNT-320-R-2014	4.47	9.68	86.16	0.00	0.01	0.00
HUNT-416-R-2014	10.82	25.71	63.33	0.00	0.23	0.00
ISRA-116-R-2014	0.00	17.22	82.75	0.00	0.00	0.00
ISRA-117-R-2014	5.69	38.92	55.14	0.00	0.25	0.00
ISRA-218-R-2014	16.60	59.96	24.53	0.00	0.09	0.00
LCCS-119-R-2014	13.34	75.43	10.14	0.00	1.08	0.00
LCCS-120-R-2014	8.34	68.07	23.59	0.00	0.00	0.00
LCCS-217-R-2014	12.29	67.52	22.47	0.00	0.33	0.00
LINL-116-R-2014	32.00	45.48	22.52	0.00	0.00	0.00

Appendix Table 1. (Continued)						
Site	**Percent Urban**	**Percent Agriculture**	**Percent Forest**	**Percent Wetlands**	**Percent Water**	**Percent Other**
LINL-118-R-2014	8.68	70.51	20.81	0.00	0.00	0.00
LINU-116-R-2014	3.63	94.28	2.08	0.00	0.00	0.00
LINU-118-R-2014	0.15	89.62	10.23	0.00	0.00	0.00
LINU-424-R-2014	16.94	54.25	28.74	0.05	0.12	0.10
LIPI-118-R-2014	9.19	23.76	24.99	0.00	0.00	0.00
LIPI-121-R-2014	1.46	0.93	0.85	0.00	0.00	0.00
LIPI-124-R-2014	8.04	79.63	12.24	0.00	0.00	0.00
MIDD-120-R-2014	2.29	9.18	88.53	0.00	0.00	0.00
MIDD-217-R-2014	8.86	27.42	63.83	0.00	0.08	0.00
MODS-117-R-2014	0.00	96.81	3.03	0.00	0.00	0.00
MODS-120-R-2014	1.24	66.44	3.86	0.00	0.00	0.00
MODS-216-R-2014	0.46	24.88	1.45	0.00	0.00	0.00
OWEN-127-R-2014	2.43	75.94	14.33	0.00	0.10	0.00
OWEN-225-R-2014	3.90	72.18	23.85	0.00	0.07	0.00
OWEN-320-R-2014	6.37	35.78	57.32	0.00	0.08	0.00
POTD-120-R-2014	6.73	89.91	5.63	0.00	0.00	0.00
POTD-324-R-2014	15.51	60.04	17.88	0.00	0.09	0.97
TOMS-116-R-2014	5.36	69.85	24.79	0.00	0.00	0.00
TOMS-120-R-2014	47.58	5.84	45.18	0.00	0.00	0.00
TUSC-116-R-2014	1.83	0.00	98.52	0.00	0.75	0.00
TUSC-417-R-2014	10.14	23.30	66.74	0.00	0.14	0.00

Appendix Table 2. Percent impervious surface in catchments upstream of sites sampled in the 2013-2014 FCSS

SiteID	Total % Impervious	SiteID	Total % Impervious
2013			
BALL-110-R-2013	6.74	LCCS-102-R-2013	2.18
BALL-112-R-2013	14.44	LCCS-201-R-2013	4.41
BALL-213-R-2013	8.27	LINL-103-R-2013	4.94
BENN-101-R-2013	3.07	LINL-108-R-2013	1.96
BENN-102-R-2013	1.90	LINL-114-R-2013	3.10
BUSL-103-R-2013	6.73	LINU-104-R-2013	3.18
BUSL-107-R-2013	15.18	LINU-107-R-2013	1.87
BUSL-301-R-2013	8.29	LIPI-106-R-2013	2.36
BUSU-113-R-2013	5.01	LIPI-110-R-2013	1.94
BUSU-209-R-2013	5.60	MIDD-101-R-2013	2.29
CARR-101-R-2013	1.99	MIDD-106-R-2013	1.76
CARR-109-R-2013	15.99	MIDD-108-R-2013	2.48
CARR-113-R-2013	5.45	MODS-101-R-2013	2.04
CATO-102-R-2013	4.06	MODS-111-R-2013	2.75
CATO-106-R-2013	3.23	OWEN-101-R-2013	5.05
FISH-106-R-2013	2.62	OWEN-202-R-2013	3.62
FISH-112-R-2013	2.14	POTD-106-R-2013	1.65
FISH-211-R-2013	3.72	POTD-107-R-2013	1.56
GLAD-104-R-2013	3.23	POTD-301-R-2013	13.45
GLAD-108-R-2013	2.05	TOMS-105-R-2013	2.05
GLAD-112-R-2013	3.26	TOMS-106-R-2013	5.05
HUNT-101-R-2013	2.12	TOMS-304-R-2013	10.35
HUNT-105-R-2013	1.58	TUSC-101-R-2013	2.98
ISRA-104-R-2013	4.37	TUSC-106-R-2013	1.66
ISRA-203-R-2013	7.44	TUSC-407-R-2013	3.34
2014			
BALL-116-R-2014	10.87	CARR-327-R-2014	8.24
BALL-118-R-2014	7.19	CATO-220-R-2014	12.83
BENN-116-R-2014	9.10	CATO-327-R-2014	8.58
BENN-121-R-2014	7.60	CATO-417-R-2014	4.57
BENN-219-R-2014	2.49	FISH-119-R-2014	1.79
BUSL-123-R-2014	2.69	FISH-223-R-2014	3.64
BUSL-316-R-2014	8.33	GLAD-117-R-2014	3.36
BUSU-116-R-2014	5.06	HUNT-221-R-2014	2.54
BUSU-123-R-2014	8.82	HUNT-320-R-2014	2.43
BUSU-221-R-2014	9.83	HUNT-416-R-2014	4.46
CARR-216-R-2014	5.98	ISRA-116-R-2014	1.57

Appendix Table 2. (Continued)			
SiteID	**Total % Impervious**	**SiteID**	**Total % Impervious**
2014 (Continued)			
ISRA-117-R-2014	2.33	MIDD-120-R-2014	1.71
ISRA-218-R-2014	8.22	MIDD-217-R-2014	2.59
LCCS-119-R-2014	8.99	MODS-117-R-2014	1.88
LCCS-120-R-2014	4.37	MODS-120-R-2014	1.43
LCCS-217-R-2014	4.59	MODS-216-R-2014	0.54
LINL-116-R-2014	4.08	OWEN-127-R-2014	1.97
LINL-118-R-2014	2.83	OWEN-225-R-2014	2.16
LINU-116-R-2014	2.15	OWEN-320-R-2014	3.57
LINU-118-R-2014	1.87	POTD-120-R-2014	2.93
LINU-424-R-2014	4.03	POTD-324-R-2014	7.94
LIPI-118-R-2014	1.77	TOMS-116-R-2014	2.18
LIPI-121-R-2014	0.18	TOMS-120-R-2014	8.04
LIPI-124-R-2014	2.63	TUSC-116-R-2014	3.03
		TUSC-417-R-2014	3.34

Site	Erosion Severity Left	Erosion Severity Right	Riparian Width Left (m)	Riparian Width Right (m)	Riparian Width Sum (m) (Sum of Left and Right)
2013					
BALL-110-R-2013	2	2	45	50	95
BALL-112-R-2013	0	0	50	50	100
BALL-213-R-2013	2	2	50	30	80
BENN-101-R-2013	1	1	50	50	100
BENN-102-R-2013	1	1	50	25	75
BUSL-103-R-2013	2	1	50	10	60
BUSL-107-R-2013	2	3	5	50	55
BUSL-301-R-2013	1	2	50	0	50
BUSU-113-R-2013	2	2	50	20	70
BUSU-209-R-2013	2	2	50	50	100
CARR-101-R-2013	1	1	20	50	70
CARR-109-R-2013	2	1	45	50	95
CARR-113-R-2013	1	1	40	40	80
CATO-102-R-2013	0	0	0	0	0
CATO-106-R-2013	1	2	20	35	55
FISH-106-R-2013	2	2	45	50	95
FISH-112-R-2013	1	1	10	50	60
FISH-211-R-2013	1	1	50	50	100
GLAD-104-R-2013	0	1	50	50	100
GLAD-108-R-2013	3	2	0	0	0
GLAD-112-R-2013	1	1	15	50	65
HUNT-101-R-2013	1	1	25	50	75
HUNT-105-R-2013	2	2	50	50	100
ISRA-104-R-2013	2	2	15	15	30
ISRA-203-R-2013	2	2	50	50	100
LCCS-102-R-2013	1	1	50	50	100
LCCS-201-R-2013	1	3	50	50	100
LINL-103-R-2013	1	1	50	25	75
LINL-108-R-2013	2	2	50	30	80
LINL-114-R-2013	1	1	40	40	80
LINU-104-R-2013	2	2	50	50	100
LINU-107-R-2013	2	2	15	5	20
LIPI-106-R-2013	2	1	50	50	100
LIPI-110-R-2013	1	1	8	8	16
MIDD-101-R-2013	1	1	50	50	100
MIDD-106-R-2013	3	2	0	0	0
MIDD-108-R-2013	1	1	25	50	75
MODS-101-R-2013	1	1	10	10	20
MODS-111-R-2013	2	2	50	50	100
OWEN-101-R-2013	2	3	50	50	100
OWEN-202-R-2013	2	2	50	50	100
POTD-106-R-2013	1	2	50	50	100
POTD-107-R-2013	2	2	50	50	100
POTD-301-R-2013	3	2	45	50	95
TOMS-105-R-2013	1	1	30	50	80

Appendix Table 3. Erosion severity and riparian buffer width for sites sampled in the 2013-2014 FCSS

Appendix Table 3. (Continued)					
Site	**Erosion Severity Left**	**Erosion Severity Right**	**Riparian Width Left (m)**	**Riparian Width Right (m)**	**Riparian Width Sum (m) (Sum of Left and Right)**
TOMS-106-R-2013	2	1	40	50	90
TOMS-304-R-2013	2	2	50	50	100
TUSC-101-R-2013	0	1	50	50	100
TUSC-106-R-2013	1	2	20	10	30
TUSC-407-R-2013	2	2	30	40	70
2014					
BALL-116-R-2014	1	1	50	50	100
BALL-118-R-2014	1	1	0	0	0
BENN-116-R-2014	2	2	50	50	100
BENN-121-R-2014	1	1	50	50	100
BENN-219-R-2014	2	1	50	50	100
BUSL-123-R-2014	2	1	50	5	55
BUSL-316-R-2014	2	1	25	50	75
BUSU-116-R-2014	2	2	8	50	58
BUSU-123-R-2014	1	1	1	50	51
BUSU-221-R-2014	1	1	50	50	100
CARR-216-R-2014	2	1	40	50	90
CARR-327-R-2014	1	1	20	30	50
CATO-220-R-2014	1	3	0	0	0
CATO-327-R-2014	3	0	50	50	100
CATO-417-R-2014	3	0	50	10	60
FISH-119-R-2014	0	0	50	50	100
FISH-223-R-2014	2	3	35	40	75
GLAD-117-R-2014	0	0	0	0	0
GLAD-121-R-2014	0	0	0	0	0
HUNT-221-R-2014	1	1	45	50	95
HUNT-320-R-2014	1	0	0	5	5
HUNT-416-R-2014	1	1	50	50	100
ISRA-116-R-2014	2	2	50	50	100
ISRA-117-R-2014	2	1	15	50	65
ISRA-218-R-2014	2	1	50	50	100
LCCS-119-R-2014	2	2	40	20	60
LCCS-120-R-2014	1	1	50	10	60
LCCS-217-R-2014	2	0	50	15	65
LINL-116-R-2014	2	1	0	0	0
LINL-118-R-2014	2	2	50	50	100
LINU-116-R-2014	2	3	50	50	100
LINU-118-R-2014	0	1	10	50	60
LINU-424-R-2014	1	1	50	50	100
LIPI-118-R-2014	1	1	0	0	0
LIPI-121-R-2014	0	0	50	35	85
LIPI-124-R-2014	3	2	0	0	0
MIDD-120-R-2014	1	1	50	50	100
MIDD-217-R-2014	0	0	5	50	55
MODS-117-R-2014	1	1	1	5	6
MODS-120-R-2014	2	2	50	50	100
MODS-216-R-2014	1	1	50	50	100

Appendix Table 3. (Continued)					
Site	**Erosion Severity Left**	**Erosion Severity Right**	**Riparian Width Left (m)**	**Riparian Width Right (m)**	**Riparian Width Sum (m) (Sum of Left and Right)**
2014 (Continued)					
OWEN-127-R-2014	1	2	0	0	0
OWEN-225-R-2014	1	1	50	50	100
OWEN-320-R-2014	3	1	50	50	100
POTD-120-R-2014	1	1	50	50	100
POTD-324-R-2014	3	3	35	20	55
TOMS-116-R-2014	0	0	40	50	90
TOMS-120-R-2014	0	0	50	50	100
TUSC-116-R-2014	0	0	50	50	100
TUSC-417-R-2014	1	2	30	30	60

* As per MBSS methods, the maximum extent of buffer measured on either side of the stream is 50m, therefore the maximum sum of the left and right buffer width reported is 100m. It is possible that the riparian buffer could extend further than 50m, but that was not reported.

Appendix Table 4. PHI and BIBI scores for sites sampled in the 2013-2014 FCSS					
SiteID	**PHI Score**	**BIBI Score**	**SiteID**	**PHI Score**	**BIBI Score**
2013					
BALL-112-R-2013	81.10	2.25	LCCS-201-R-2013	78.71	2.25
BALL-213-R-2013	62.63	2.50	LINL-103-R-2013	62.21	2.25
BENN-101-R-2013	75.41	2.25	LINL-108-R-2013	66.76	1.75
BENN-102-R-2013	66.25	1.75	LINL-114-R-2013	70.46	3.25
BUSL-103-R-2013	50.16	3.50	LINU-104-R-2013	63.68	4.25
BUSL-107-R-2013	50.21	2.25	LINU-107-R-2013	50.19	1.50
BUSL-301-R-2013	71.51	3.50	LIPI-106-R-2013	73.60	2.75
BUSU-113-R-2013	61.10	4.00	LIPI-110-R-2013	54.28	1.75
BUSU-209-R-2013	72.10	3.50	MIDD-101-R-2013	94.42	4.25
CARR-101-R-2013	57.13	4.25	MIDD-106-R-2013	38.60	3.50
CARR-109-R-2013	58.68	2.75	MIDD-108-R-2013	71.74	3.75
CARR-113-R-2013	70.18	1.75	MODS-101-R-2013	40.67	2.00
CATO-102-R-2013	48.87	2.25	MODS-111-R-2013	90.23	2.50
CATO-106-R-2013	63.86	4.50	OWEN-101-R-2013	70.59	3.25
FISH-106-R-2013	57.76	2.25	OWEN-202-R-2013	80.58	3.50
FISH-112-R-2013	57.53	2.00	POTD-106-R-2013	88.55	3.25
FISH-211-R-2013	74.75	3.50	POTD-107-R-2013	73.12	4.25
GLAD-104-R-2013	59.60	1.75	POTD-301-R-2013	57.27	2.50
GLAD-108-R-2013	28.55	1.50	TOMS-105-R-2013	55.79	2.00
GLAD-112-R-2013	64.01	1.75	TOMS-106-R-2013	61.17	3.25
HUNT-101-R-2013	73.29	4.50	TOMS-304-R-2013	86.97	3.00
HUNT-105-R-2013	82.00	4.50	TUSC-101-R-2013	88.33	3.25
ISRA-104-R-2013	51.88	1.25	TUSC-106-R-2013	62.28	3.00
ISRA-203-R-2013	79.01	2.75	TUSC-407-R-2013	63.92	3.75
LCCS-102-R-2013	82.77	3.25			
2014					
BALL-116-R-2014	77.48	2.25	CATO-220-R-2014	40.11	2.25
BALL-118-R-2014	44.34	2.00	CATO-327-R-2014	78.33	2.25
BENN-116-R-2014	73.45	2.50	CATO-417-R-2014	42.36	3.00
BENN-121-R-2014	70.80	3.50	FISH-119-R-2014	93.62	4.25
BENN-219-R-2014	86.49	3.50	FISH-223-R-2014	62.85	3.25
BUSL-123-R-2014	53.01	1.75	GLAD-117-R-2014	37.47	1.75
BUSL-316-R-2014	75.94	1.75	GLAD-121-R-2014	43.83	1.75
BUSU-116-R-2014	44.73	3.25	HUNT-221-R-2014	84.73	3.25
BUSU-123-R-2014	48.07	2.25	HUNT-320-R-2014	48.99	3.50
BUSU-221-R-2014	80.32	3.25	HUNT-416-R-2014	77.09	3.50
CARR-216-R-2014	70.97	1.75	ISRA-116-R-2014	74.65	2.50
CARR-327-R-2014	50.80	2.25	ISRA-117-R-2014	57.09	3.00

Appendix Table 4. (Continued)					
SiteID	**PHI Score**	**BIBI Score**	**SiteID**	**PHI Score**	**BIBI Score**
2014 (Continued)					
ISRA-218-R-2014	70.09	2.75	MIDD-217-R-2014	57.31	4.00
LCCS-119-R-2014	52.26	3.00	MODS-117-R-2014	42.05	1.25
LCCS-120-R-2014	57.68	1.75	MODS-120-R-2014	71.98	3.25
LCCS-217-R-2014	68.24	2.75	MODS-216-R-2014	69.44	2.50
LINL-116-R-2014	47.66	4.50	OWEN-127-R-2014	40.00	2.50
LINL-118-R-2014	71.06	2.50	OWEN-225-R-2014	74.81	2.00
LINU-116-R-2014	72.54	3.75	OWEN-320-R-2014	75.25	3.25
LINU-118-R-2014	66.87	1.50	POTD-120-R-2014	85.40	2.50
LINU-424-R-2014	74.26	2.50	POTD-324-R-2014	44.79	2.50
LIPI-118-R-2014	35.54	3.50	TOMS-116-R-2014	56.58	1.25
LIPI-121-R-2014	59.93	2.50	TOMS-120-R-2014	79.17	2.25
LIPI-124-R-2014	36.54	2.50	TUSC-116-R-2014	84.12	2.50
MIDD-120-R-2014	76.05	4.25	TUSC-417-R-2014	65.50	3.75

Appendix Table 5. Water Quality Parameters for Sites Sampled in the 2013-2014 FCSS. Turbidity is measured in NTUs; all other values are in mg/L

Site	Dissolved Organic Carbon	Turbidity	Total Phosphorus	Total Nitrogen	Ortho-Phosphate	Ammonia - N	Nitrite - N	NitrateN-NitriteN	Nitrate - N	TKN
2013										
BALL-110-R-2013	1.0668	2	0.008	2.3009	0.0037	0.0098	0.0046	2.3309	2.3263	-0.03
BALL-112-R-2013	0.4011	10	0.0138	4.0182	0.0083	0.0073	0.0045	3.7942	3.7897	0.224
BALL-116-R-2014	1.3506	0	0.0078	3.3992	0.0043	0.0101	0.0044	3.2187	3.2143	0.1805
BALL-118-R-2014	1.1841	1	0.0078	2.6701	0.0035	0.0048	0.0021	2.6184	2.6163	0.0517
BALL-213-R-2013	1.1138	3	0.0107	3.6678	0.0031	0.0137	0.0138	3.7166	3.7028	-0.0488
BENN-101-R-2013	1.5753	4	0.0137	1.3334	0.003	0.0303	0.0108	1.1509	1.1401	0.1825
BENN-102-R-2013	1.617	17	0.042	9.8687	0.0044	0.0263	0.0139	9.8875	9.8736	-0.0188
BENN-116-R-2014	1.0243	4	0.0223	3.6884	0.0173	0.0043	0.0026	3.5819	3.5793	0.1065
BENN-121-R-2014	1.6402	6	0.0189	2.4849	0.0114	0.005	0.0017	2.3354	2.3337	0.1495
BENN-219-R-2014	1.527	8	0.0184	1.8825	0.0051	0.0061	0.0039	1.7027	1.6988	0.1798
BUSL-103-R-2013	0.8201	7	0.0094	4.6681	0.0024	0.0084	0.0171	4.6045	4.5874	0.0636
BUSL-107-R-2013	0.7399	6	0.0132	2.8115	0.0011	0.0109	0.0086	2.7975	2.7889	0.014
BUSL-123-R-2014	1.9071	15	0.0675	4.9391	0.0076	0.0072	0.0041	4.375	4.3709	0.5641
BUSL-301-R-2013	0.953	1	0.0403	3.0611	0.0273	0.0225	0.0221	2.9967	2.9746	0.0644
BUSL-316-R-2014	0.9359	2	0.0232	3.5458	0.0131	0.013	0.0167	3.4223	3.4056	0.1235
BUSU-113-R-2013	0.6616	2	0.0084	3.5749	0.0015	0.0104	0.0024	3.5946	3.5922	-0.0197
BUSU-116-R-2014	1.0713	12	0.0205	3.056	0.0027	0.0095	0.0021	3.0401	3.038	0.0159
BUSU-123-R-2014	1.3757	2	0.0125	3.3853	0.0062	0.0053	0.0017	3.3445	3.3428	0.0408
BUSU-209-R-2013	0.8493	1	0.0083	3.4408	0.0012	0.0058	0.0045	3.4811	3.4766	-0.0403
BUSU-221-R-2014	1.0931	7	0.0303	3.0041	0.0147	0.0073	0.0101	2.8341	2.824	0.17
CARR-101-R-2013	0.202	4	0.008	0.5247	0.0033	0.0053	0.0027	0.4246	0.4219	0.1001
CARR-109-R-2013	1.317	19	0.0776	2.4577	0.0017	0.008	0.0138	1.6557	1.6419	0.802
CARR-113-R-2013	0.4261	3	0.0117	7.6016	0.0041	0.0074	0.0018	7.581	7.5792	0.0206
CARR-216-R-2014	1.2334	0	0.0078	2.1425	0.0037	0.0051	0.007	1.9664	1.9594	0.1761
CARR-327-R-2014	0.8357	1	0.0114	3.0051	0.0062	0.0115	0.0094	2.8034	2.794	0.2017
CATO-102-R-2013	1.3621	2	0.0216	8.9946	0.0057	0.0151	0.0259	8.938	8.9121	0.0566
CATO-106-R-2013	0.9396	3	0.0173	0.5078	0.0118	0.0063	0.001	0.4115	0.4105	0.0963
CATO-220-R-2014	1.7554	1	0.2638	3.9649	0.238	0.0098	0.0177	3.6845	3.6668	0.2804
CATO-327-R-2014	1.7828	2	0.1694	4.6004	0.1491	0.0047	0.0201	4.2766	4.2565	0.3238
CATO-417-R-2014	1.6062	1	0.0152	1.7449	0.0064	0.0034	0.0081	1.548	1.5399	0.1969
FISH-106-R-2013	2.5875	5	0.0262	0.4447	0.0051	0.0255	0.0031	0.0481	0.045	0.3966
FISH-112-R-2013	2.3361	5	0.0253	3.1093	0.0156	0.0073	0.0036	3.0705	3.0669	0.0388
FISH-119-R-2014	0.7597	8	0.0108	0.3249	0.0097	0.0036	0.0011	0.2665	0.2654	0.0584
FISH-211-R-2013	1.4789	1	0.008	0.2809	0.0013	0.0052	0.0025	0.1735	0.171	0.1074
FISH-223-R-2014	1.6402	2	0.012	0.9136	0.0028	0.0048	0.0034	0.7421	0.7387	0.1715

Appendix Table 5. (Continued)										
Site	**Dissolved Organic Carbon**	**Turbidity**	**Total Phosphorus**	**Total Nitrogen**	**Ortho-Phosphate**	**Ammonia - N**	**Nitrite - N**	**NitrateN-NitriteN**	**Nitrate - N**	**TKN**
2013 (Continued)										
GLAD-104-R-2013	0.9611	8	0.0483	7.985	0.0112	0.0211	0.0231	7.7487	7.7256	0.2363
GLAD-108-R-2013	18.5223	1052	5.4619	15.9899	2.0805	0.6227	0.0969	4.7987	4.7018	11.1912
GLAD-112-R-2013	1.6985	1	0.0576	7.656	0.0248	0.0266	0.0327	7.4131	7.3804	0.2429
GLAD-117-R-2014	1.2722	6	0.0874	7.973	0.0445	0.0227	0.0343	7.6353	7.601	0.3377
GLAD-121-R-2014	2.9035	1	0.0885	7.2372	0.0602	0.0184	0.1044	6.8009	6.6965	0.4363
HUNT-101-R-2013	0.9739	1	0.008	0.5232	0.0029	0.0038	0.001	0.4825	0.4815	0.0407
HUNT-105-R-2013	1.6514	3	0.0095	0.3105	0.0043	0.0053	0.0022	0.2173	0.2151	0.0932
2014										
HUNT-221-R-2014	1.5869	3	0.0265	0.9585	0.0139	0.0067	0.0033	0.7037	0.7004	0.2548
HUNT-320-R-2014	1.5459	1	0.0131	0.5023	0.0062	0.0047	0.0016	0.3744	0.3728	0.1279
HUNT-416-R-2014	1.6823	1	0.0084	0.9465	0.0039	0.0074	0.0051	0.75	0.7449	0.1965
ISRA-104-R-2013	4.234	2	0.0183	0.6925	0.0051	0.0139	0.001	0.2943	0.2933	0.3982
ISRA-116-R-2014	1.043	1	0.0086	1.3268	0.0036	0.004	0.0017	1.1938	1.1921	0.133
ISRA-117-R-2014	0.9743	2	0.0078	1.7318	0.0028	0.0044	0.002	1.6062	1.6042	0.1256
ISRA-203-R-2013	1.788	1	0.0235	2.2816	0.0079	0.0084	0.0224	2.1348	2.1124	0.1468
ISRA-218-R-2014	1.8073	3	0.0217	3.3776	0.0052	0.0029	0.0116	3.1879	3.1763	0.1897
LCCS-102-R-2013	0.6395	10	0.0404	2.1949	0.0227	0.01	0.0016	2.1459	2.1443	0.049
LCCS-119-R-2014	1.5912	1	0.0111	1.8916	0.0064	0.0058	0.0039	1.6947	1.6908	0.1969
LCCS-120-R-2014	2.1912	6	0.0385	1.8361	0.0084	0.0099	0.0035	1.6171	1.6136	0.219
LCCS-201-R-2013	2.2266	2	0.0188	2.6705	0.0042	0.0319	0.0674	2.4548	2.3874	0.2157
LCCS-217-R-2014	2.0178	2	0.0205	3.6162	0.0058	0.0043	0.0174	3.3764	3.359	0.2398
LINL-103-R-2013	0.8769	1	0.0182	2.0982	0.0088	0.0042	0.002	1.9735	1.9715	0.1247
LINL-108-R-2013	1.3822	15	0.0298	4.8198	0.0051	0.0094	0.0121	4.7334	4.7213	0.0864
LINL-114-R-2013	0.5759	2	0.0131	3.4038	0.0063	0.0087	0.0026	3.384	3.3814	0.0198
LINL-116-R-2014	0.5705	1	0.0078	3.8424	0.0031	0.0075	0.0031	3.7486	3.7455	0.0938
LINL-118-R-2014	1.003	4	0.0188	5.8621	0.0048	0.0041	0.0134	5.3601	5.3467	0.502
LINU-104-R-2013	0.8271	21	0.008	2.6026	0.0033	0.0054	0.0065	2.576	2.5695	0.0266
LINU-107-R-2013	2.1856	1	0.0734	6.29	0.0469	0.0507	0.0944	5.3648	5.2704	0.9252
LINU-116-R-2014	0.9181	5	0.0271	5.2403	0.0189	0.0061	0.0011	5.1063	5.1052	0.134
LINU-118-R-2014	3.5939	5	0.1944	4.6585	0.1245	0.0132	0.0423	4.1238	4.0815	0.5347
LINU-424-R-2014	1.4033	12	0.0282	3.2678	0.0098	0.0066	0.006	3.099	3.093	0.1688
LIPI-106-R-2013	1.0539	5	0.0148	4.9855	0.0047	0.008	0.0155	4.847	4.8315	0.1385
LIPI-110-R-2013	0.3864	37	0.0454	6.9336	0.0037	0.0094	0.0022	6.2797	6.2775	0.6539
LIPI-118-R-2014	1.5477	7	0.0199	3.3319	0.0102	0.0082	0.0026	3.1659	3.1633	0.166
LIPI-121-R-2014	1.8658	3	0.0284	3.7017	0.0197	0.0207	0.0071	3.5833	3.5762	0.1184
LIPI-124-R-2014	1.5645	6	0.0374	4.6279	0.0185	0.0061	0.0053	4.4224	4.4171	0.2055

Appendix Table 5. (Continued)										
Site	**Dissolved Organic Carbon**	**Turbidity**	**Total Phosphorus**	**Total Nitrogen**	**Ortho-Phosphate**	**Ammonia - N**	**Nitrite - N**	**NitrateN-NitriteN**	**Nitrate - N**	**TKN**
2014 (Continued)										
MIDD-101-R-2013	1.0946	0	0.008	1.2176	0.0041	0.0043	0.001	1.1723	1.1713	0.0453
MIDD-106-R-2013	1.2125	1	0.0241	1.5732	0.0082	0.0046	0.001	1.5295	1.5285	0.0437
MIDD-108-R-2013	1.3949	0	0.008	0.9889	0.0046	0.0027	0.001	0.9324	0.9314	0.0565
MIDD-120-R-2014	1.156	2	0.0079	0.8419	0.0048	0.0048	0.0013	0.7165	0.7152	0.1254
MIDD-217-R-2014	1.2728	0	0.0078	1.1029	0.0039	0.0034	0.0013	0.9633	0.962	0.1396
MODS-101-R-2013	1.4049	8	0.015	5.1831	0.0043	0.0144	0.0116	5.04	5.0284	0.1431
MODS-111-R-2013	2.1999	2	0.0131	2.4398	0.007	0.0063	0.0032	2.3795	2.3763	0.0603
MODS-117-R-2014	2.4818	2	0.0295	8.9944	0.0083	0.0059	0.0065	8.2556	8.2491	0.7388
MODS-120-R-2014	1.9772	11	0.0344	4.6108	0.0147	0.0121	0.0085	4.3192	4.3107	0.2916
MODS-216-R-2014	1.5452	3	0.0164	5.5957	0.0091	0.0078	0.0141	5.3993	5.3852	0.1964
OWEN-101-R-2013	3.2859	4	0.014	0.3988	0.0027	0.0068	0.0041	0.1523	0.1482	0.2465
OWEN-127-R-2014	2.9409	7	0.0451	2.3043	0.0309	0.0054	0.0053	1.9658	1.9605	0.3385
OWEN-202-R-2013	2.2996	3	0.0093	0.6467	0.0015	0.0058	0.004	0.4944	0.4904	0.1523
OWEN-225-R-2014	2.1072	2	0.0093	1.397	0.0036	0.0057	0.0036	1.1495	1.1459	0.2475
OWEN-320-R-2014	1.3625	0	0.0078	1.1967	0.0052	0.0035	0.0031	1.0355	1.0324	0.1612
POTD-106-R-2013	1.4813	4	0.0096	2.1549	0.0062	0.006	0.001	2.1478	2.1468	0.0071
POTD-107-R-2013	1.2237	1	0.0085	1.0449	0.0056	0.0069	0.001	0.9704	0.9694	0.0745
POTD-120-R-2014	2.3466	5	0.044	3.9003	0.0223	0.0076	0.0066	3.7541	3.7475	0.1462
POTD-301-R-2013	1.2232	5	0.0151	4.6386	0.0044	0.01	0.0211	4.5761	4.555	0.0625
POTD-324-R-2014	2.1356	8	0.0349	4.4182	0.0118	0.0077	0.0084	4.1713	4.1629	0.2469
TOMS-105-R-2013	4.2867	7	0.0364	1.8366	0.0103	0.0114	0.0088	1.4026	1.3938	0.434
TOMS-106-R-2013	1.5295	3	0.0298	1.0763	0.0146	0.0163	0.0062	0.9223	0.9161	0.154
TOMS-116-R-2014	3.8836	1	0.0752	4.6962	0.0519	0.0206	0.0032	4.1644	4.1612	0.5318
TOMS-120-R-2014	0.8093	0	0.0078	1.5717	0.0047	0.0046	0.0015	1.4575	1.456	0.1142
TOMS-304-R-2013	2.2766	2	0.0092	0.9116	0.0019	0.0046	0.0057	0.7594	0.7537	0.1522
TUSC-101-R-2013	0.5362	0	0.008	0.1619	0.0011	0.002	0.001	0.0796	0.0786	0.0823
TUSC-106-R-2013	1.0301	4	0.0218	0.8322	0.0018	0.0127	0.0023	0.6936	0.6913	0.1386
TUSC-116-R-2014	0.9419	0	0.0078	0.139	0.0011	0.003	0.0011	0.0849	0.0838	0.0541
TUSC-407-R-2013	1.0695	1	0.0132	0.6426	0.0059	0.0053	0.0037	0.528	0.5243	0.1146
TUSC-417-R-2014	1.3866	1	0.0182	0.9557	0.0077	0.0066	0.0031	0.783	0.7799	0.1727

* TKN is calculated as Total Nitrogen – Nitrate Nitrogen. TN and Nitrate-N are calculated using different methods, sometimes resulting in Nitrate-N being slightly larger than TN, which would result in a negative TKN value.